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ABSTRACT

This study focused on five major activities: (1) developing an achievement test to measure visual diagnostic ability of television service technicians, (2) assessing the independence of the dimension of visual diagnostic ability, (3) comparing the iconic equivalence of photographs with motion cues and live screen presentations of defective television pictures for testing purposes, (4) ascertaining if static and dynamic tests are measures of a single dimension, and (5) assessing the reliability of the two tests. Static and dynamic tests were administered to 89 students who were completing 1-year programs in radio-television servicing, and to 24 radio-television technicians. A panel of radio-television instructors and technicians wrote the questions and judged the appropriateness of items for the test. Several hypotheses were analyzed as results of the tests. A copy of the directions for the tests, and computer printouts are appended. (AG)

AN ICONIC COMPARISON OF PHOTOGRAPHS AND THE LIVE TELEVISION SCREEN IN VISUAL DIAGNOSTIC ABILITY

Jarrel Hofer

National Center for Occupational Education

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PREFACE

One of the primary aims of a teacher's lesson structure should be to present material in such a way that the students can not only repeat accurately the facts learned, but also apply the principles in a practical situation. It is to be hoped that this practice would be maintained in fields ranging from applied mathematics to driver education. The point is to be able to relate facts learned in the classroom to problems existing outside the classroom.

Inherent in this kind of preparation is the assumption that the material presented to the students is a true and realistic representation of knowledge to be of use in everyday situations. A film used in a driver education class to illustrate traffic hazards will be of no benefit at all if it does not depict realistically those dangers the driver will find on the highway. Similarly, an auto mechanic-to-be cannot be expected to recognize a faulty generator if the model used in the classroom is not a faithful representation of the real thing.

This technical paper presents still another dimension of the equivalence of training and practice in industry. The field is television repair, and this multi-purpose study delves into several aspects of the training, testing, and performance of the television service technician.

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John K. Coster
Director

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CHAPTER I

INTRODUCTION

Nature of the Problem

One of the most important jobs a television service technician performs is diagnosis. Obviously, the technician does many other things, but unless he can perform this first step he is essentially useless as a technician. It does not take exceptional skill or knowledge to test vacuum tubes, solder wires, replace components, etc. Most people can be taught to do these things in a very short time; however, it does take considerable knowledge and skill to diagnose problems that occur in television receivers. Anyone who has closely observed a technician servicing a television set has seen the technician constantly observing the picture from the set as he performs certain checks, makes adjustments, or replaces components. The quality of the picture is a constant reference point in servicing a television receiver. The video (picture) and audio (sound) are the end products of the set's circuitry, and their quality is really the technician's major concern. In fact, he is highly concerned with both normal and defective reception and must be able to distinguish between them. One dealer estimates that 25 percent of all service calls involve normal reception ("Education and Inventory," 1969).

The inherent circuit characteristics of television receivers are such that the signal progresses through the set in a systematic manner generally characteristic of all television receivers, e.g., all television circuits contain low and high voltage, power supplies, horizontal and vertical oscillator, I. F., and audio and video stages. These stages are interconnected, and their final product is the video and audio output in the form of picture and sound. If some stage (or parts of a stage) in the receiver malfunctions, it will affect the quality of the picture in some manner which is quite characteristic; e.g., a malfunctioning vertical oscillator can cause the picture to roll or move vertically, lack of high voltage will cause the screen to go dark, AC current leaking into the audio will cause a hum in the sound, etc. This visual cue in the picture and/or audio cue in the sound immediately tells the technician which stage or stages he should examine in the set to locate the trouble; that is, it narrows the field of his search for the faulty component(s). Obviously, the technician uses other skills and knowledges in locating malfunctions in a television receiver, but visual diagnosis is always first. All malfunctions could, in theory, be diagnosed and located with an oscilloscope and other test equipment. In practice, however, this just is not done because it is easier and quicker to look at the picture tube for these cues since the television receiver acts as its own test equipment. However the technician must be able to read the screen just as he must be able to read a voltmeter or oscilloscope Instructional programs for training television technicians teach the use of these cues systematically and/or incidentally--it can hardly be escaped Yet there is little or no effort to measure this visual diagnostic ability in evaluating technicians graduating from technical training programs A cursory survey of the market reveals only one or two television chassis with switchable defects wired in so that they may be used for testing and/or teaching purposes Some instructors wire their own sets, but this is expensive and time consuming. More often, only the instructor's opinion enters into the evaluation of the student technician's ability to visually diagnose television malfunctions. Yet if we are to get a complete assessment of the ability of the technician, all dimensions of his ability must be measured. A fairly large number of research studies have been made of electronic troubleshooting; however, none has been addressed to the task of assessing the visual diagnostic ability of television service technicians

Another method of presenting defective television pictures to technicians for testing purposes is photography Photographs have many advantages over the live television screen for testing purposes. They are smaller, more convenient, cheaper to produce in large quantities, more consistant easily transportable and more reliable. (Electronic equipment malfunctions; photographs do not.) Many electronic textbooks, trade magazines, and trouble-shooting pamphlets for the layman use photographs for these reasons The question of the equivalence of the photographs to the live picture should be asked--how good are these photographic substitutes? They obviously lack the motion found in a live television picture, but if they are of high quality and of sufficient size to resolve the picture detail, they contain all of the remaining information in the picture since they are an exact copy. The books and pamphlets mentioned previously do, in fact, contain supplementary statements wherever necessary which are indicative of any motion in the picture, e.g., rolling picture, jumping picture, etc. If the qualifications of size, quality, resolution, and motion cues are given, we would expect the photographs to be equivalent, or nearly so, to the live screen presentation for testing purposes. No studies have been made of the relationship between photographs with motion cues and a live screen television picture. It is imperative that the question of equivalence be answered for economic and logistic reasons if the dimension of visual diagnostic ability is to be tested extensively.

Purpose of the Study

This study was an attempt to answer several basic questions with regard to an additional dimension of the performance of television service technicians and the equivalence of two methods of presenting defective television reception for testing purposes. The first purpose of the study was to develop a test to measure an additional dimension of the performance of the television service technician which is not being measured by a conventional paper and pencil test--visual diagnostic ability. The second purpose of the study was to assess the independence of the dimension of visual diagnostic ability from the knowledge which is normally measured by paper and pencil tests. The third purpose of the study was to develop a parallel form of the test in order to compare the iconic equivalence of photographs with verbal motion cues and live screen presentations of defective television pictures for testing purposes. Iconicity is defined as the degree of realism with which an object represents the real object. One can scale objects according to their iconicity. In the case of television pictures, the scale might be: line drawings, shaded line drawings, still photographs, and motion pictures. In each case as the degree of iconicity increases, the representation is more like the real object. The fourth purpose of the study was to ascertain if the static and dynamic tests are measures of a single dimension, and, further, if they are both measures of the same dimension. The fifth purpose of the study was to assess the reliability and validity of the two tests.

Limitations of the Study

The study was limited to attempting to develop parallel forms of an instrument for assessing the existence and independence of the dimension of visual diagnostic ability of graduating television servicing technicians and assessing the iconic equivalence of two methods of presenting defective pictures. No attempt was made to assess all of or the relative importance of the dimensions of troubleshooting ability. Since this study was an attempt to answer basic questions about visual diagnostic ability and iconic equivalence, and due to the cost of equipment and logistics of testing, only a sampling of black and white vacuum tube-type television receiver malfunctions were used. No attempt was made to test the visual capacity of the technicians or students tested. Visual testing would have created additional logistic and financial problems, and there was no reason to suspect that any of the students or technicians tested had any visual impairment which might affect their performance on the tests. It seemed reasonable that visual impairment to this extent would have eliminated those affected from the training programs or from the occupation. No attempt was made to establish the minimum acceptable size of photographs. High quality photographs of sufficient size to allow resolution of single scan lines were assumed to be adequate.

CHAPTER II

LITERATURE SURVEY AND STATEMENT OF HYPOTHESES

Literature Survey

The value of performance testing has been recognized for centuries. Performance tests are effective, have great realism, and a close relationship to job-like measures. They have high face validity (Evans and Smith, 1953) and are intrinsically valid (Fattu, 1956, p. 3). One of the earliest records of performance testing goes back to Biblical times. Jephthah (Jud. 12:5) used the password "Shibboleth" because he knew the enemy could not pronounce the sound "sh". All those fugitives at the Jordan fords who said Sibboleth were promptly killed. It was a very effective test (Fattu, 1956, p. 2). Performance tests do have some serious drawbacks, though. They usually cost more, consume more time to administer, and allow only a limited sampling of the tasks the individual should be able to do (Lefkowith, 1955, p. 17). Their advantages, however, outweigh their disadvantages. Their big advantage is that they appear to measure an additional dimension of the criterion.

It has been shown many times through research that human ability is multidimensional and, indeed, that dimensions may have subdimensions. Such is the case with electronic troubleshooting ability. Saupe concluded that some but not all variance due to individual differences in troubleshooting can be predicted from basic knowledge (Saupe, 1954, pp. 74-75). If, in fact, this is the case, in order to assess the criterion adequately we must sample all dimensions of the criterion, not merely those dimensions that are easy or convenient to measure. Even though the importance and the need for performance tests have been recognized, their development has lagged behind. This is especially true in the vocational-technical field; yet this is one area that should be making wide use of performance tests since most of the abilities with which we are concerned require more than just cognitive knowledge. Instead of developing performance tests, other forms of tests have been substituted that are cheaper and easier to develop and administer. Electronic troubleshooting, in particular television troubleshooting, is no exception. Sometimes pictorial tests have been substituted for performance tests which use actual equipment, but even these are rather rare (Lefkowith, 1955, p. 1).

Saupe (1954) identified troubleshooting as one of the most crucial and difficult jobs of the electronic technician. Standlee et al. (1956) report that according to the Navy electronic technicians' handbook, troubleshooting ability is a sort of sixth sense which is acquired with experience. If this is the case, it lends even more support to the logic for testing this dimension. The ability to troubleshoot electronic equipment is a critical job requirement for electronics technicians; yet the research shows that there has been heavy reliance on paper and pencil tests which may not measure this dimension. There is strong evidence that such tests measure principally verbal content and that visual tests are needed to measure visual content (Holmes, 1959, p. 76).

There has been much research done in the area of electronic troubleshooting. The vast majority of these studies have been made for the military and are concerned primarily with specific military applications such as maintenance of radio and radar equipment. The three largest categories of this electronic research are proficiency assessment techniques, training equipment or materials, and analysis of job activities. Other categories are evaluation of maintenance personnel, experimental, and general. There have also been many troubleshooting tests developed which can be categorized into (1) on-the-job measures, (2) performance tests, (3) simulator tests, (4) ARC (Automatic Recording of Checks) tests, and (5) paper and pencil tests.

Miller and Folley (1951) define troubleshooting as a logical procedure in eliminating the alternative possibilities in diagnosing the cause of a symptom or group of symptoms. The technician does this by performing appropriate checks, by a logical or systematic procedure, or from probability data. It should be recognized, however, that before the technician can troubleshoot a given piece of equipment, he must first be able to recognize (discriminate) that the symptom or problem exists, i.e., he must know the operating characteristics of the equipment well enough to recognize abnormal operation under the usual operating conditions of the equipment. One study points up quite well the process involved in troubleshooting as well as the importance of the ability of the electronics technician to troubleshoot electronic equipment. In this study the investigator had electronics technicians rank the abilities they felt their jobs required. He concluded that the first three critical requirements of electronics technicians are to (1) make simple discriminations, (2) make decisions contingent upon these discriminations, and (3) analyze and trace circuits (Standlee et al., 1956). Although most of the troubleshooting research and tests deal with specific military problems and are not pertinent to this study, there are a number of findings which are important.

Many people have observed and studied technicians' troubleshooting equipment and have noted the wide differences in the ability of the technicians to diagnose quickly and/or successfully malfunctioning equipment. Bryan et al. (1956) made such an observation. Saupe (1954) observed technicians troubleshooting a superheterodyne radio and concluded that basic knowledge predicts some but not all of the individual differences in troubleshooting proficiency and that good troubleshooters know more about the functional relationships between components than do poor troubleshooters. Acquisition of sufficient information to locate the defective stage does not guarantee a correct solution, but it does increase the chances of success. Highland and others concluded that successful troubleshooters do not necessarily make fewer checks. In fact, there is no particular advantage in accomplishing a large number of checks before restricting the checking to a single stage of the equipment. However, a tendency to make more checks in "wringing" out a stage improves a man's chances for locating the trouble. The nearer a man's first component relacement is to the defective component, the more likely it is that he will eventually find the trouble. Interviews conducted with troubleshooters suggested that rapid solution of trouble-shooting problems is associated with logical analysis and thinking out the problem, knowledge of the equipment, past experience with the particular malfunction, and proper utilization of test equipment (Saltz and Moore, 1953).

The research presented thus far indicates that troubleshooting ability is a critical duty of the technician and that there are large individual differences in this ability among technicians. Basic knowledge accounts for some but not all of these differences, and successful troubleshooters cannot necessarily be identified by the number of checks made. Successful troubleshooting is contingent upon making discriminations, making decisions based upon these discriminations, and tracing and analyzing circuits. Also, visual tests should be used to measure visual content.

In the specific case of the television service technician, the troubleshooting process starts with discriminations about picture quality or lack of picture and proceeds to the second step, that of making decisions based upon the discriminations, i.e., identification or recognition of the symptoms followed by elimination of possible causes. Glaser Damrin and Gardner developed a ARC (Automatic Recording of Checks)-type television troubleshooting test for a problem-solving research study. Verbal descriptions were used as the means of indicating picture quality (Fattu, 1956). However, when performance testing, the prime testing device is the actual equipment in its normal setting. When this is not feasible, a simulator or pictorial test should be substituted (Wulfeck and Taylor, 1957). Uris (1955) found that three-dimensional models and actual equipment were both better than two-dimensional aids in teaching complex motor skills. Lefkowith (1955) studies the iconic relationship of various methods of teaching and testing. He defines iconicity as realism, or the degree to which pictorial signs or symbols are similar to the objects signified. He concluded that pictorial tests measure learning best when the testing device is as nearly like the actual equipment as possible and that the testing should be done with the same equipment or pictorial representation as used in teaching. He further concludes that there is a practical limit beyond which increased reality in a pictorial test will not result in increased validity and that there is a point beyond which a higher iconic level will not add relevant learning (or testing) cues. Motion picture films and kinescopes have been found to be almost as effective as conventional means in teaching classes (Holmes, 1959). Motion pictures, if of sufficient quality, should contain all of the relevant information presented by an actual television screen; however, these are expensive to produce. Still photographs are reasonably cheap and easy to reproduce but lack motion and are one step more removed iconically from the live television screen. If the iconic level of photographs with motion cues is sufficiently high, these would provide a cheaper, more convenient, and more reliable method of testing the visual diagnostic ability of television technicians. This question has not yet been researched fully.

In testing the visual diagnostic ability of television technicians, one cannot escape certain questions pertaining to vision. One of these is the relationship between static and dynamic vision. Burg (1966) has made an extensive study of California drivers' static and dynamic vision. Studies of this nature typically use a target moving in an arc in front of the subject's eyes with the speed and direction of the target varying. He found that (1) acuity declines with the speed of the target, (2) there is a high correlation between static and dynamic vision, and (3) the correlation decreases as the target speed increases (December, 1964). Ludwigh and Miller concluded that visual acuity is largely dependent upon the efficiency of the overall ocular pursuit mechanism of the individual and that not all persons with good static acuity are equally good in dynamic acuity (Bartley, 1958). Dynamic vision may be a critical variable when comparing photographs with a live television screen. This has not yet been researched. Since the motion that may be present in the picture of a malfunctioning television receiver approaches a static condition and since the relevant cue is motion rather than the speed of motion, it seems reasonable that if photographs of a television screen are supplemented with motion cues, they should be essentially equal to the live screen presentations.

Visual perception has been researched by Von Senden, Bailley, Forgus, Gibson, Vernon, and others. Von Senden reports that perception is multidimensional, with dimensions of space, size, form, brightness, color, etc. In studying persons who were given sight for the first time, Von Senden found that differences in the dimensions of color and brightness could be detected immediately; however, practice was required before other dimensions could be accurately discriminated (Riesen, 1947). In other words, learning takes place as a result of practice. Gibson and Gibson concluded that perceptual learning leads to increased specificity or differentiation of the perceptual act, i.e., the individual becomes more sensitive to the variables of the stimulus array. VanderMeer (1953) concluded that students improve their ability to learn from films as they have more practice in viewing films. Zuckerman and Rock (1957), Forgus (1966), Dember (1964), and Birch (1945) also conclude that perceptual learning increases with experience. Since experience plays an important part in visual perception, we would expect that experienced technicians would tend to score higher than graduating technicians on a visual diagnostic test of malfunctioning television receivers since they have had a greater amount of experience (Fehrer, 1935, and Dickinson, 1926).

When testing using a live television screen, the viewing position and distance from the screen may be critical. In studying instructional television programs, Holmes (1959) found that the maximum number of students viewing one screen should be approximately equal to the screen size expressed in feet. He also found no difference in achievement in students sitting in the front, middle, or rear of the room when the minimum and maximum distances from the screen were the screen size expressed in feet and twice the screen size in feet, respectively. Ash et al. (1953) found the optimum viewing area of a rear projection daylight screen to be a 60 degree cone, 12 screen widths deep, expressed in feet. When servicing a television set, a technician typically views the set from close range primarily because he must be close in order to work on the set. As long as the malfunctions presented are such that they do not require observation of individual scan lines, e.g., focus problems it would seem reasonable to expect that viewing conditions similar to those for instructional television and rear projection equipment should be adequate, although it would seem advisable to restrict the maximum distance as much as practicable.

It should be noted that troubleshooting as previously defined requires three steps--discrimination, decision-making, and circuit tracing and analysis. For purposes of this study a distinction will be made between diagnosis and troubleshooting. Diagnosis as used here refers to the first two steps--discrimination and decision-making. This process isolates one stage or a series of stages in order of probable fault within which further isolating checks can be made. In some cases it might pinpoint a single component. Troubleshooting is taken to mean the entire process which includes the additional step of circuit tracing and analysis to isolate the defective component(s). Thus, visual diagnostic ability of the technician refers to his ability to look at a television screen, make discriminations, and then make decisions about these discriminations, i.e., he must be able to look at the screen and recognize normal or abnormal reception and then, if the reception is abnormal, make a decision about the probable source.

Statement of Hypotheses

The following research hypotheses were formulated based upon the research studies just cited.

1. Visual diagnostic ability exists as a reliable dimension as measured by the static test.

2. Visual diagnostic ability exists as a reliable dimension as measured by the dynamic test.

3. As measured by the static test, visual diagnostic achievement of television technicians employed full time in the occupation will be significantly better than the visual diagnostic ability of students completing training.

4. As measured by the dynamic test, visual diagnostic achievement of television technicians employed full time in the occupation will be significantly better than the visual diagnostic achievement of students completing training.

5. There is no significant difference in iconicity between photographs with verbal motion cues and live set presentations of malfunctions in visually diagnosing television receiver malfunctions.

6. Visual diagnostic ability as measured by the static test is independent of other trade-related knowledge as measured by a paper and pencil test of knowledge of basic electronics.

7. Visual diagnostic ability as measured by the dynamic test is independent of other trade-related knowledge as measured by a paper and pencil test of knowledge of basic electronics.

8. Visual diagnostic ability as measured by the static test represents essentially a single dimension.

9. Visual diagnostic ability as measured by the dynamic test represents essentially a single dimension.

10. The static and dynamic tests measure the same dimension.

CHAPTER III

EXPERIMENTAL PROCEDURE

Restatement of the Problem

This study was an attack on several basic questions regarding the assessment of an additional dimension of achievement of graduating student television service technicians and the iconic equivalence of photographs with verbal motion cues and the live screen as methods of presenting defective television reception for testing purposes. The first part of the problem was to develop a test to assess the additional dimension of visual diagnostic ability which is not normally measured with a paper and pencil test. The second part of the problem was to develop a parallel test to assess the iconic equivalence of photographs with verbal motion cues and live screen presentations of defective television reception for testing purposes. The third part of the problem was to assess the independence of visual diagnostic ability from that which is normally measured by conventional paper and pencil tests. The fourth part of the problem was to assess the visual diagnostic dimension with regard to its being a single valid and reliable dimension. Some of the basic relationships to be studied are shown diagrammatically as follows:

knowledge of basic electronics
paper and pencil test

↕ ↕

visual diagnostic ability live screen ⟷ visual diagnostic ability photographs with verbal motion cues

Test and Equipment Development

A panel of radio-television instructors and technicians from North Carolina and Illinois wrote the items for the tests and judged their appropriateness. The panel had been previously employed by the Achievement Measures Project to write a standardized radio-television service curriculum to be used in one-year technical training programs in radio and television service. The panel was also responsible for writing an achievement test for radio-television servicing. This was a paper and pencil test of knowledge of basic electronics. It is referred to here as the RTV test and is used in part of the analysis of this study (Baldwin, 1968). Items were written and judged for appropriateness by the panel. Those items upon which there was greatest agreement and which could be suitably wired into a set were retained for use in the tests.

Malfunctions used were wired into a television chassis so that they could be switched into and out of the circuit at the appropriate time. The unit chosen for this purpose was a Tele-Lab instructor model manufactured and supplied by R. W. S. Industries, Cleveland, Ohio. The trainer is approximately four feet high by 22 inches wide and 16 inches deep. A 16-inch picture tube is mounted near the top with the chassis mounted near the bottom. An auxiliary chassis and panel were mounted on the unit in front of the main chassis to carry the switches and necessary components to switch in malfunctions. Except for the means of presenting malfunctions, the static and dynamic tests are identical. Twenty-seven different malfunctions were used with 50 multiple-choice questions based on these malfunctions. Some malfunctions were used for more than one question since they are more common. For purposes of this study only black and white tube type malfunctions were used. Two further restrictions on the malfunctions used were: they had to be switchable into the circuit of the set without destroying the set; and they had to be compatible with the set circuitry, e.g., low DC restorer voltage problems could not be used since the set uses B+ boost. A standard test pattern was used as the video signal so that the same signal was fed into the television set in all instances. A B&K 1076 television analyst was used for this purpose.

Audio cues are sometimes used in the diagnosis of a set and could normally be heard from a live set but obviously would be lacking in photographs. To control this variable the audio portion of the set was blocked out so that no audio signal could be heard. A statement on the condition of the audio was included in each question in both the static and dynamic tests. Statements such as normal audio, hum in audio, weak audio, distorted audio, etc. were used.

A question in the static test would read as follows:

1. The most likely cause of the malfunction in Figure #1 with normal audio is:

   A. defective vertical oscillator stage

   B. defective high voltage rectifier

   C. defective horizontal output stage

   D. defective DC restorer stage

The same question in the dynamic test would read:

1. The most likely cause of the malfunction presented on the screen with normal audio is:

   A. defective vertical oscillator stage

   B. defective high voltage rectifier

C. defective horizontal output stage

D. defective restorer stage

The screen on the trainer was utilized as the photographic model for the static test. Malfunctions were switched into the circuit, and then the screen was photographed on 3 X 5 film. The negatives were then masked, two to a page, with just the screen and bezel of the set showing. Photographic prints were made and inserted in the test so that the photograph was directly opposite the question pertaining to the photograph. Screen size in the photographs is approximately 2 3/4" X 3 1/2". The photographs used in the static test were of high quality with individual scan lines easily discernible. A normal screen photograph was placed in the front of the static test for reference purposes.

The Sample

The static and dynamic tests were administered to 89 students and 24 technicians. All the students were completing one-year technical post-high school training programs in radio-television servicing. The students were enrolled in ten technical institutes across North Carolina and one in South Carolina. These schools were using the standardized radio-television curriculum written by the panel, and they had also been visited by the staff of the Achievement Measures Project to ensure that the curriculum being taught in all of the schools was the same. The RTV test was also administered to the students, but at a different sitting.

All the technicians were employed full-time as technicians in television service departments. Twelve of them were attending a special inservice training program at the Sears-Roebuck training center in Chicago. They came from Michigan, Wisconsin, Illinois, and Indiana. Twelve other technicians were tested from the local community of Champaign-Urbana, Illinois. These technicians were paid to take the tests.

Test Administration

Since the trainer was transported from school to school and local conditions varied, it was necessary to warm up and tune the equipment at each administration of the test. This was done in the absence of the subjects. The test was administered in normally lighted electronics laboratories or classrooms equipped with arm chairs for writing. Since the groups were small it was relatively easy to seat the subjects within the 60 degree cone, 32 feet deep, that is ideal for viewing television. The subjects were asked if they could see the screen satisfactorily, and when all were satisfied, the general directions for the test were read to the group. (See Appendix A.) The subjects were then told that they could expect three kinds of malfunctions, those which affect only the video, those which affect only the audio, and those which affect both the audio and video. The test was then started with each malfunction being switched on for one minute for each question it involved. This was followed by a few seconds of display of the normal picture before switching in the next malfunction. The screen was covered while the malfunctions were switched into the circuit. Upon completion of the dynamic test, the static test was administered in a similar manner except that the subjects were able to work at their own rate since the malfunctions were presented by photographs.

The trainer generally performed excellently throughout the testing. Humidity and local conditions affected the trainer, but these effects were counteracted by letting the set warm up, followed by tuning. Only once did a malformation occur during testing. A solder joint broke allowing a wire to drop off. Fortunately, this affected a malfunction which was easily described verbally to the subjects. It was necessary for logistic and economic reasons to administer both static and dynamic tests at one sitting. Since both tests are identical and there was a possibility of a learning effect and other variables which might influence the outcome, approximately one-half of the subjects were administered the static test first and one-half, the dynamic test first. For logistic reasons all subjects at a given school were administered the two tests in the same sequence. It was necessary, therefore, to divide the subjects, by school, into those who were administered the static test first and those who were administered the dynamic test first. The tests were alternately administered first unless the size of the two groups became unbalanced because of unequal numbers of subjects among the schools. If the difference in size of the two groups became too great, one test was administered first until the size of the two groups was again nearly equal.

CHAPTER IV

RESULTS

This study dealt primarily with (1) the existence of a visual diagnostic dimension and its relationship to basic electronics knowledge and (2) the iconic equivalence of photographs with verbal motion cues and dynamic live screen presentations of television malfunctions for testing purposes. Some associated questions were also studied. The hypotheses are stated explicitly in Chapter II.

Eighty-nine students were tested with the static and dynamic tests. Means of 24.99 for the static test and 26.24 for the dynamic test were obtained. The standard deviations were 6.04 and 5.65 for the static and dynamic tests, respectively. The highest attained scores were 39 on the static test and 40 on the dynamic test. The range of scores was 31 on the static test and 26 on the dynamic test. The mean difficulty level for items on the static test was .498; on the dynamic, .525. Table 1 summarizes the results of these tests. A full discussion of the tests is not included here; the data are presented so that the reader will have a better understanding of the tests as the analyses of the hypotheses are presented.

The general reaction of the students and technicians toward the tests was very good; considerable interest and enthusiasm were shown. It was evident that the face validity of the tests was high. This would be expected since the subjects were solving real problems. Many of the students and some of the technicians thanked the author after completing the test. This is in the author's experience, unusual.

Table 1. Statistical Summary of the Static and Dynamics Tests for Students

Measure	Static	Dynamic
N	89	89
Mean	24.99	26.24
Variance	36.46	31.93
Standard deviation	6.04	5.65
Standard error of measurement	3.46	3.47
Highest attained score	39	40
Range	31	26
Reliability K-R #14	.728	.698
Coefficient of discrimination	.960	.965
Mean difficulty level	.498	.525

Hypotheses 1 and 2 state that the static and dynamic tests are reliable measures. Reliability in this case is interpreted as an indication of internal consistency. A reliability index was computed for both the static and dynamic tests using the Kuder-Richardson formula 14. This gave a reliability index of .728 for the static test and .698 for the dynamic test. These reliabilities are only moderately high but are acceptable for the purposes of this study; therefore, hypotheses 1 and 2 are accepted. While these reliabilities are only moderately high, they are higher than might be expected for a test of this type for several reasons. This type of test has not been used previously, and, therefore, the technique and instruments have not been perfected. For example, it is not known whether the size of the photograph is critical, how close one must be in order to properly observe the screen for testing purposes, or what the best method of presenting motion cues is.

Several bits of feedback from students and technicians after they took the tests may help explain why the reliabilities were not higher. Wording of the questions seemed to confuse in two ways. The questions were stated in the form: "The most likely cause . . . ." Some students and technicians interpreted this to mean the order in which they would check out a given malfunction. In many cases a check might be carried out to eliminate a possible source of a malfunction simply because it is easier to make this check than it is to check out the most probable source of the malfunction. In actual practice, making these preliminary checks prior to checking out the most probable source of a malfunction could potentially save considerable time; however, with regard to the static and dynamic tests, this procedure could lead to a wrong conclusion. The second difficulty with the wording concerned the manner in which the answers were stated, e.g., if one of the alternative answer read "defective damper" or "defective damper circuit," there was a tendency to read this as defective damper tube since the tube is the most probable cause of problems in the damper circuits. This tendency to interpret the questions in terms of the most likely component within the entire circuit may also have led to faulty conclusions with regard to the static and dynamic tests.

Some of the subjects apparently failed to read, and, consequently, consider, some of the cues when selecting an answer. This was true of the audio cues on both tests and either the motion cue or some other pertinent cue in the photograph on the static test. There was a tendency on the part of many subjects, especially the technicians, to want to get more information from the schema or to change controls on the set before making a choice of answers. This is, no doubt, a normal reaction to being faced with a decision-making situation with only limited information.

Part of the analysis concerns the relationships between the static and dynamic tests and the RTV test, a test of knowledge of basic electronics. Of the 89 students who took the static and dynamic tests, 84 also took the RTV test. These 84 students were used in the analysis of variance tests and in the correlations which were used to test several hypotheses. The change in sample size caused only slight changes in the means. The means for the sample of 84 appear in Table 2.

Since each student was tested on both the static and dynamic tests at a single sitting, the question of the effect of order of testing arises. An effort to control this variable was made by administering each test first to approximately one-half of the students. The order of testing was tested with an analysis of variance. Table 2 is a summary of the cell N's and means for this two-way analysis of variance comparison. Table 3 summarizes the results of this analysis.

Table 2 Summary of Analysis of Variance, Cell Means, and N

Order of Testing	Iconicity: Static	Iconicity: Dynamic	Means
Static first	N = 41	N = 41	
	$\bar{X}$ = 25.000	$\bar{X}$ = 26.146	$\bar{X}$ = 25.573
Dynamic first	N = 43	N = 43	
	$\bar{X}$ = 25.186	$\bar{X}$ = 26.303	$\bar{X}$ = 25.744
Means	$\bar{X}$ = 25.090	$\bar{X}$ = 26.220	$\bar{X}$ = 25.660

Table 3. Analysis of Variance Summary, Order of Testing and Iconicity

Source	Degrees of Freedom		Mean Square	F Ratio	Probability
Iconicity (Static/Dynamic)	1	82	53.720	7.88	< .01
Interaction	1	82	.00984	.00139	> .05
Order of testing	1	82	1.227	.0189	> .05

As can be seen from Table 3, the analysis shows an F ratio of .0189 for order of testing, which is a very small F ratio and not significant at the .05 level. Therefore, order of testing made no difference, i.e., there was no significant learning or practice effect from having been administered the static or dynamic test first.

Hypotheses 3 and 4 stated that the technicians would do significantly better than graduating students on the static and dynamic tests. The statistics for the static and dynamic tests for the 24 technicians are summarized in Table 4.

Table 4. Statistical Summary of the Static and Dynamic Tests for Technicians

Measure	Static	Dynamic
N	24	24
Mean	32.13	33.29
Variance	33.24	35.61
Standard deviation	5.77	5.97
Standard error	3.32	3.26
Reliability K-R #14	.740	.779

A summary of the analysis of variance is found in Table 5. It can be seen from this table that the technicians did significantly better than the students, supporting the hypothesis of construct validity. The F ratio of 29 for this test is significant beyond the .01 level. The hazards of drawing conclusions from small samples is recognized; however, the sample is nearly large statistically, and the difference is very highly significant.

Table 5. Analysis of Variance Summary, Validity and Iconicity

Source	Degrees of Freedom		Mean Square	F Ratio	Probability
Iconicity (Static/Dynamic)	1	106	70.0416	10.02	$< .01$
Interaction	1	106	.0119	—	$> .05$
Validity (Students/ Technicians)	1	106	1854.3065	29.00	$< .01$*

*This is a one-tailed test.

Since the intended purpose here is merely to show that the technicians do better than students, this check of construct validity is adequate for the purpose of this study. It is concluded, therefore, that the static and dynamic tests are valid measures and that hypotheses 3 and 4 are accepted.

Hypothesis 5 states that photographs with verbal motion cues are iconically equivalent to a live set presentation of malfunctions in visually diagnosing television receiver difficulties. A product-moment correlation of .81 was found between the static and dynamic tests. This is a rather high correlation indicating a strong relationship between the two tests and supporting the hypothesis of equivalence of the two tests. Some caution is needed here, however, in that the .81 correlation may be spuriously high. The highest correlation that is theoretically possible between the two tests is the square root of the product of their reliabilities. In this case the square root of the product of .728 and .698 would give .71 as the highest correlation that could reasonably be expected between the two tests. The obtained correlation of .81 may not be unrealistic, however, because the instruments and testing techniques have not been perfected; as the reliabilities of the tests are improved the correlation between the tests should also improve. If the correlation between the static and dynamic tests is corrected for attenuation, a correlation slightly greater than unity is obtained. This leads one to suspect that the assumptions underlying the reliabilities have been violated. In this case the reliabilities were found with the Kuder-Richardson formula 14, which assumes that the tests are measures of a single factor and have inter-item correlations. It will be shown in a later discussion that the static and dynamic tests are not measures of a single dimension, and an examination of the item intercorrelations shows that they vary considerably. If the assumptions of the formula are violated, the reliabilities are underestimated. Underestimated reliabilities could account for the corrected correlation's exceeding unity, and the highest theoretical correlation possible between the static and dynamic tests would also be underestimated. This evidence indicates that the obtained correlation of .81 between the static and dynamic tests may not be unrealistic and may, in fact, be an underestimate of the correlation corrected for attenuation. A high correlation between the static and dynamic tests is strong evidence of equivalence of the tests, and this is seen as additional support for the hypothesis.

Additional tests of hypothesis 5, the equivalence of the static and dynamic tests, were made using analysis of variance. One analysis of variance comparison of the static and dynamic tests which included only students is summarized in Table 3. This comparison gave an F ratio of 7.88, which is significant beyond the .01 level. The difference between the means of the static and dynamic tests in this comparison is 1.13 points. The static and dynamic tests were also compared as part of the analysis of variance summarized in Table 5 and included both students and technicians. An F ratio of 10.02, which is significant beyond the .01 level, was obtained. The difference between the means of the static and dynamic tests in this comparison was 1.14 points. In order to be equivalent, tests must have equal means and variance and have a high correlation (Gulliksen, 1950, pp. 173-192). It can be seen that there is only partial support from the statistical tests for this hypothesis; therefore, hypothesis 5 is rejected. As was pointed out, the differences between the means were 1.13 points for the students and 1.14 points for the students and technicians combined. This small difference might be attributed to factors other than chance. There is reason to believe, for example, that differences in item difficulty could be such a factor. Easy or difficult items which appear in one test but not in the other could have the effect of adding or subtracting a constant from the mean of the static or dynamic test, which could account for the small differences in this case. If an easy item is defined as an item marked correctly by 90 percent or more of the subjects, then the static and dynamic tests are not equal in this respect. Using this criterion, the dynamic test contained three easy items--numbers 18, 33, and 45. Only one easy item is contained in the static test--item 33. Item 18 used loss of vertical deflection as the malfunction, producing a horizontal white line in the center of a dark screen. Item 33 used a dark screen as the malfunction, and item 45 used a defective AGC-sync system as the malfunction. This malfunction causes simultaneous vertical and horizontal movement of the picture. Differences of this type could explain the small difference between the obtained means. There would appear to be no difference in the iconic presentation of these items unless the subjects missed the motion cue on item 45. A horizontal bar or a dark screen is just that, whether it is presented by photograph or live screen.

The difference between the means of the two tests could also be explained in terms of iconic differences of the tests. It should be pointed out that either the live screen or the photographs could have been better iconically under the testing conditions in which the static and dynamic tests were administered. Since the tests were identical except for the method of presenting the malfunction, any large difference in the proportion of students correctly marking an item might be attributed to an iconic difference. An examination of the item analysis (Appendix B) shows that eight items differ by more than .100 in the proportion passing on the static and dynamic tests. Item 38 was marked correctly by a greater proportion of the students on the static test. Items 8, 12, 28, 37, 39, 42 and 49 were marked correctly by a greater proportion of the students on the dynamic test. Some of these items used a malfunction which was used in several other questions. If there is an iconic difference for a malfunction, then this difference should occur in all items using that particular malfunction, and all of the items should agree that one method of presenting the malfunction is better. For example, if there is an iconic difference between the methods of presenting malfunctions, then for three items using the same malfunction we would expect to find that a greater proportion of the subjects would correctly mark all three items on, say, the dynamic test. Sixteen malfunctions were each used in more than one question. The expectations, if an iconic difference exists, are found to hold true for nine of the sixteen malfunctions that were used in more than one question. Two others essentially meet these expectations, and four do not. ~~Of the~~ eleven that essentially meet these expectations, seven indicate that the dynamic method is better. Four indicate that the static is better. The malfunctions which appear to be iconically better in the dynamic test require discriminations of degree such as weak reception, weak video, whether the raster is normal with the absence of video output, etc., and also the dark screen. The static test seems to be better for presenting oscillator, power supply filter, and damper circuit problems.

The criteria of equal means, equal variance, and a high correlation are very rigorous requirements for equivalence of tests. Of these requirements the most important is a high correlation, which shows a close relationship between the tests. Differences between means can be compensated for by adding or subtracting a constant from the means of the tests to bring the scores to the same standard score. Many published, well recognized tests do not have equal means on equivalent forms of the test, and they use this procedure. Although the static and dynamic tests do not in the strictest sense meet the requirements of equivalent tests, from a practical standpoint the tests are equivalent.

Hypotheses 6 and 7 state that the static and dynamic tests are measures of a dimension which is independent of trade-related cognitive knowledge as measured by a paper and pencil test of knowledge of basic electronics. The RTV test is a three hundred-item, multiple choice paper and pencil achievement test in radio-television servicing developed as a part of the Achievement Measures Project of which this study is a part. The RTV test was administered to 149 students and has a mean and standard deviation of 114.43 and 39.56, respectively, for this sample. Those students who took the static and dynamic tests are included in the sample. The reliability of the RTV test as measured by the Kuder-Richardson 14 formula is .96. The static test correlated .58 and the dynamic .60 with the RTV test. These rather high correlations indicate a fairly high degree of relationship of the static and dynamic tests to the RTV test; therefore, they are not independent, and hypotheses 6 and 7 are rejected. It should be pointed out, however, that if these correlation coefficients are squared, only about 35 percent of the variance of one can be accounted for by the other. This indicates a fairly large degree of specificity in the static and dynamic tests. Even though visual diagnostic ability is not entirely independent of knowledge of basic electronics, it may still be desirable to test this dimension in assessing achievement.

Hypotheses 8 and 9 state that the static and dynamic tests each measure a single dimension. The static and dynamic tests were factor analyzed by means of a principal axis factor analysis program with varimax rotation to study these relationships. The static and dynamic tests accounted for almost equal amounts of the total variance in each case. The static test accounted for 26.70 percent of the total variance, and the dynamic test, 26.34 percent of the total variance. Table 6

Table 6. Percentage of Common Variance Accounted for by Rotated Factors for the Static and Dynamic Tests

	Factors			
Test	One	Two	Three	Four
Static	39.07	21.33	20.05	19.54
Dynamic	42.07	20.38	19.32	18.23

summarizes the percentage of common variance accounted for by each of the rotated factors for the static and dynamic tests. The two analyses gave results which were quite similar; however, the static test accounted for slightly more variance in all cases except factor one. Factor one of the dynamic test accounted for slightly more variance than factor one of the static test. Although one strong factor is emerging in each case, the remaining three factors are strong with reference to factor one. On the static test, factors two, three, and four accounted for 54.6, 51.3, and 50.0 percent, respectively, of the amount of variance accounted for by factor one. On the dynamic test, factors two, three, and four accounted for 48.4, 45.9, and 43.3 percent, respectively, of the amount of variance accounted for by factor one. The analyses indicate that the static and dynamic tests are not single dimension tests; therefore, hypothesis 8 and 9 are rejected.

Hypothesis 10 states that the static and dynamic tests are measures of the same dimension. A question was raised concerning whether different mental processes are used to solve the various kinds of malfunctions presented in the two tests. Several technicians were quizzed on how they solved the problems on the tests. The process described is as follows: examine the set and try to determine what parts or stages are working and how well; then eliminate possible sources of the malfunction on the basis of knowledge of the relationship between the components and on past experience. This is the same process described by Miller and Folley (1951) and Saupe (1954) and is also the author's opinion of the mental process involved--the process of logical reasoning. Unless there is some subtle difference that is not recognized, the same process is used for all of the problems involved in the tests.

Three kinds of problems were used in the tests--those which involved the audio (or sound) only, those which involved the video (or picture) only, and those which involved both the audio and video output. When the higher factor loadings (.2 or larger) were examined with reference to the kinds of problems involved, some interesting relationships were revealed. Both tests factored in a similar manner on the four factors with regard to the type of malfunction used in the questions. Questions which loaded on factor one dealt with all three kinds of malfunctions and in very nearly the same proportions in which they were presented within the tests as a whole. Those questions which dealt with strictly video problems were not quite as heavily loaded on factor one in proportion to their occurrence in the tests as a whole.

For test security reasons, the static and dynamic tests are not included in this report; however, four sample items and four photographs from the static test are included in Appendix C to give the reader some idea of the kinds of problems used and the quality of the photographs. For ease of reproduction, the motion cues are given beside the question rather than beside the photograph, as was the case in the static test.

Factor two contained almost equal numbers of pro .ems affecting the video only and affecting both the audio and video. Since the tests have a higher proportion of problems which affect only the video, this would tend to de-emphasize the video type of problems for factor two and to emphasize those problems which affect both the audio and the video.

Factor three contained almost entirely video problems alone. One audio problem loaded on this factor on the dynamic test only.

Factor four contained all three types of problems, but it appears to contain a relatively large proportion of audio problems. Three-fourths of the audio problems loaded on this factor, while proportionally only one-third to one-half of the video and audio-video problems loaded on this factor. It is difficult to tell if this is an indication that the audio is the strong element in this factor or if it is similar in character to factor one with slightly different emphasis. There were only four questions which dealt with strictly audio problems, and, hence, a small change here would make it appear that a much greater emphasis is on audio problems than is actually the case.

As just discussed, there was some indication that the factors contained different kinds of problems in different proportions. The items were summarized according to the effect the malfunction had on the audio and video output. This raised the question about whether the source of the malfunction had any relationship to the factor upon which an item loaded. The items were summarized according to the source of the malfunction as indicated by the correct answer to the question. No particular relationship seemed to be indicated between the source of the malfunction and the factor upon which the item loaded.

Since the items did not load with equal magnitude on the static and dynamic tests for a given factor, an attempt was made to summarize the data by ranking the loadings for each item. The loadings for each item were ranked so that the highest loading for an item was ranked one; the second highest, two; the next, three; and the lowest loading, four. These ranks were then summarized. When summarized in this manner, about two-thirds of the items loaded identically for the static and dynamic tests on their highest (first ranked) loadings. In some cases the difference between a one rank and a two rank is small, and if these items are also considered, then the proportion would go a little higher. About 20 of these items are located in factor one, with progressively fewer items in the other factors. Six of the second-ranked loadings and five of the third-ranked loadings were on identical items on the two tests.

Evidence has been cited here which indicates that the items loaded on the factors in a similar manner on both tests with regard to the relative magnitude of the loadings and the types of malfunctions. This suggests that the tests are measures of the same dimension. The static and dynamic tests correlated in a similar manner with the RTV test which gives further support to the acceptance of hypothesis 10. The static test correlated .58 and the dynamic test .60 with the RTV test. This evidence, with the evidence previously sighted, seems to indicate that the static and dynamic tests are measures of the same dimension; therefore, hypothesis 10 is accepted.

The evidence is not conclusive, so caution must be exercised in interpretation of the factors. Tentatively, factor one is named the general visual diagnostic factor. Factor two is tentatively named the video-audio factor, and factor three, the video factor. Evidence is not sufficient to place a name on factor four.

CHAPTER V

SUMMARY AND CONCLUSIONS

Summary

This research centered around two major problems: (1) to develop an achievement test to measure the additional dimension of visual diagnostic ability and (2) to test the iconic equivalence of photographs with motion cues and live screen presentations of defective television reception for testing purposes. Related questions concerning reliability, validity, and the dimensions of visual diagnosis were also studied.

Method of Study

A panel of radio-television instructors and technicians was utilized to write questions and judge the appropriateness of items for the test. The malfunctions were wired into a Tele-Lab trainer so that they could be switched in, at will, for presentation during the test. Fifty multiple-choice questions representing 27 malfunctions were used. The malfunctions affected the audio only, the video only, or both the audio and the video. This test is the Visual Diagnostic Test for Television Servicing-Dynamic, or the dynamic test. The live screen used in the dynamic test served as the photographic model for the Visual Diagnostic Test for Television Servicing-Static, or the static test. Verbal motion cues were presented beside each photograph on the static test. The static and dynamic tests were identical except for the method of presenting the visual information in the malfunctions. To equalize the two tests, a statement of the audio condition was presented within each question.

The static and dynamic tests were administered to 89 students who were completing one-year programs in radio-television servicing. For economic and logistic reasons, the students were administered both the static and dynamic tests in one sitting. They were divided into two groups so that approximately one-half of them took the static test first and one-half took the dynamic test first. The students also took, at a different sitting, a three hundred-item, multiple choice test of knowledge of basic electronics, the RTV test.

The static and dynamic tests were also administered to a sample of 24 technicians who were employed full-time in radio-television servicing,

Results and Conclusions

Hypotheses 1 and 2 stated that the static and dynamic tests are reliable. The Kuder-Richardson formula 14 yielded a validity index of .728 and .698, respectively, for the static and dynamic tests This is a moderately high reliability; however, since the equipment and testing procedures have not been perfected, this reliability was considered adequate. Hypotheses 1 and 2 were accepted.

Hypotheses 3 and 4 stated that the static and dynamic tests are valid measures Students and technicians were compared using analysis of variance. An F ratio of 29.31 was obtained, which is significant beyond the .01 level; therefore, hypotheses 3 and 4 were accepted.

Hypothesis 5 stated that photographs with verbal motion cues are equivalent to live screen presentations of defective television reception for testing purposes. A product-moment correlation of .81 was obtained between the static and dynamic tests. A correlation of .71 is the highest correlation that is theoretically possible between the tests, estimated from the reliabilities of the tests, and is less than the obtained correlation. When corrected for attenuation, the correlation is slightly greater than unity. (The assumptions underlying the reliability formula were violated, giving an underestimate of the reliabilities. This could explain why the obtained correlation was higher than theoretically possible and also why the correlation corrected for attenuation is greater than unity.) A high correlation was considered to be strong evidence that the tests are equivalent. The static and dynamic tests were also compared by analysis of variance. F ratios of 7.88 for students and 10.02 for students and technicians were obtained and are significant beyond the .01 level. Only partial support was given to this hypothesis from the statistical tests, so hypothesis 5 was rejected. The requirements of equivalence are quite rigorous and are frequently not met by well recognized tests. The static and dynamic tests do meet the most important requirements of equivalence; therefore, from a practical standpoint, the tests may be considered equivalent.

Hypotheses 6 and 7 stated that the static and dynamic tests are independent of trade-related cognitive knowledge as measured by a paper and pencil test of knowledge of basic electronics (RTV). The static test correlated 58 and the dynamic test .60 with the RTV test. These correlations indicate a reasonably strong relationship; therefore, the static and dynamic tests are not independent, and hypotheses 6 and 7 were rejected.

Hypotheses 8 and 9 stated that the static tests each measure a single dimension. The tests were factor analyzed using a principal axis factor analysis with varimax rotation. The results of the analysis indicate that, on both the static and dynamic tests, factors two, three, and four are each about one-half as strong as factor one. This indicates a more complex relationship rather than a single dimension; therefore, hypotheses 8 and 9 were rejected.

Hypothesis 10 stated that the static and dynamic tests are measures of the same dimension. This relationship was studied with factor analysis. The results indicate that the items of the two tests do load on the factors in a similar manner. The factors of the two tests were also similar with regard to the kinds of problems that loaded on each of the factors. The static test correlated .58 and the dynamic test correlated .60 with the RTV test. The results of the factor analysis and the correlations were taken as evidence that the static and dynamic tests are measures of the same dimension. Therefore, hypothesis 10 was accepted.

Implications for Further Research

1. If visual diagnostic ability is widely tested, suitable photographic models and/or live screen equipment must become readily available.

2. If visual diagnostic ability is widely tested, the instruments should be broadened and expanded to include a wider range of black and white malfunctions and transistor and color circuits.

3. Technicians expressed much concern about the efficiency of the overall trouble-shooting process, of which visual diagnosis is a part. The use of photographs coupled with some other device, such as a schematic or tab test, may offer premise as a practical method of evaluating the overall efficiency of a technician to carry through the entire trouble-shooting procedure. This should be researched.

4. There was a small but significant difference between the means of the static and dynamic tests. Additional research should be done to ascertain whether these differences can be accounted for by such factors as size of photographs or method of presenting motion cues.

5. Additional research should be done on the validity of tests of visual diagnostic ability. The differences found between students and technicians could be accounted for by either performance or experience.

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APPENDIX A

GENERAL TEST DIRECTIONS

GENERAL DIRECTIONS - STATIC TEST

This is a performance test in television servicing. It is designed to test the knowledge which you have acquired during your course of study.

This is a timed test. You will have a total of 50 minutes to complete the entire test. Malfunctions are presented in the photographs at the left. You will be required to examine the photograph and determine the malfunction from the answers which you have in your test booklet.

Read all of the answers carefully before choosing an answer.

The questions on this test are multiple choice and require you to blacken the letter space on the answer sheet corresponding to the answer which is correct or most nearly correct. An example is given below:

Example: The decimal equivalent of 1/16 is:

A. .00625
B. .01625
C. .0625
D. .625

The correct answer is C, so C would be blackened on the answer sheet as indicated below:

Illustration of the Answer Sheet

<u>Do not</u> write in the test booklet. Record all your answers on your answer sheets.

<u>DO NOT TURN THIS PAGE UNTIL TOLD TO DO SO</u>

GENERAL DIRECTIONS - DYNAMIC TEST

This is a performance test in television servicing. It is designed to test the knowledge which you have acquired during your course of study.

This is a timed test. You will have a total of 50 minutes to complete the entire test. Malfunctions will be presented on the screen. You will be required to examine the screen and determine the malfunction from the answers which you have in your test booklet.

Read all of the answers carefully before choosing an answer.

The questions on this test are multiple choice and require you to blacken the letter space on the answer sheet corresponding to the answer which is correct or most nearly correct. An example is given below:

Example: The decimal equivalent of 1/16 is:

A. .00625
B. .01625
C. .0625
D. .625

The correct answer is C, so C would be blackened on the answer sheet as indicated below:

Illustration of the Answer Sheet

Do not write in the test booklet. Record all your answers on your answer sheets.

DO NOT TURN THIS PAGE UNTIL TOLD TO DO SO

APPENDIX B

COMPUTER PRINTOUT

March 17, 1969 Baldwin ACH MEAS Student Static CRIT IS TOT SCR JT2151

Item Information

Item Number	Correct Response	Weight	Proportion Passing	Proportion Omitting	Proportion Of Selecting Each Response A	B	C	D	Biserial R	Item-Total
1	(B)	1.0	.456	.000	.178	.456	.044	.322		.730
2	(D)	1.0	.456	.000	.089	.289	.167	.456		.262
3	(D)	1.0	.700	.011	.033	.033	.222	.700		.110
4	(A)	1.0	.711	.011	.711	.067	.122	.089		.241
5	(A)	1.0	.444	.000	.444	.067	.433	.056		.430
6	(B)	1.0	.522	.000	.133	.522	.289	.056		.072
7	(D)	1.0	.544	.000	.233	.167	.056	.544		.610
8	(D)	1.0	.689	.000	.056	.056	.200	.689		.269
9	(A)	1.0	.200	.000	.200	.444	.300	.056		.770
10	(D)	1.0	.222	.000	.200	.522	.056	.222		.520
11	(C)	1.0	.411	.000	.078	.300	.411	.211		.314
12	(A)	1.0	.333	.000	.333	.156	.433	.078		.554
13	(A)	1.0	.511	.000	.511	.367	.089	.033		.602
14	(C)	1.0	.244	.011	.456	.211	.244	.078		-.022
15	(B)	1.0	.611	.000	.111	.611	.144	.133		.152
16	(C)	1.0	.867	.000	.022	.067	.867	.044		.392
17	(D)	1.0	.600	.000	.078	.022	.300	.600		.541
18	(C)	1.0	.878	.000	.067	.011	.878	.044		.562
19	(D)	1.0	.156	.011	.167	.200	.467	.156		
20	(D)	1.0	.489	.011	.069	.056	.356	.489		
21	(D)	1.0	.356	.022	.067	.500	.056	.356		
22	(B)	1.0	.556	.011	.156	.556	.211	.067		
23	(A)	1.0	.167	.011	.167	.033	.344	.444		
24	(C)	1.0	.311	.000	.122	.078	.311	.489		.429
25	(D)	1.0	.522	.000	.156	.111	.211	.522		.423
26	(D)	1.0	.422	.000	.356	.122	.100	.422		.298
27	(A)	1.0	.800	.000	.800	.078	.022	.100		.623
28	(B)	1.0	.389	.011	.189	.389	.167	.244		.040
29	(D)	1.0	.422	.000	.289	.211	.078	.422		.246
30	(C)	1.0	.600	.000	.033	.078	.600	.289		.317

March 17, 1969 Baldwin ACH MEAS Student Static CRIT IS TOT SCR JT2151

Item Information

Item Number	Correct Response	Weight	Proportion Passing	Proportion Omitting	Proportion Of Selecting Each Response A	B	C	D	Biserial R Item-Total
31	(B)	1.0	.822	.011	.044	.822	.122	.000	.006
32	(B)	1.0	.533	.000	.089	.533	.133	.244	.585
33	(D)	1.0	.900	.000	.022	.011	.067	.900	.429
34	(A)	1.0	.622	.000	.622	.067	.089	.222	.390
35	(B)	1.0	.689	.000	.011	.689	.056	.244	.295
36	(B)	1.0	.411	.000	.189	.411	.067	.333	.499
37	(D)	1.0	.311	.000	.133	.500	.056	.311	.127
38	(D)	1.0	.533	.000	.033	.067	.367	.533	.349
39	(B)	1.0	.533	.000	.078	.533	.044	.344	.137
40	(A)	1.0	.289	.000	.289	.478	.178	.056	.266
41	(A)	1.0	.478	.011	.478	.144	.189	.178	.228
42	(D)	1.0	.489	.011	.078	.044	.378	.489	.666
43	(A)	1.0	.156	.022	.156	.067	.500	.256	-.107
44	(B)	1.0	.556	.022	.000	.556	.322	.100	.184
45	(D)	1.0	.822	.011	.056	.078	.033	.822	.373
46	(D)	1.0	.800	.011	.100	.067	.022	.800	.531
47	(A)	1.0	.156	.022	.156	.500	.056	.267	.155
48	(C)	1.0	.222	.011	.289	.333	.222	.144	-.091
49	(D)	1.0	.578	.044	.200	.078	.100	.578	.473
50	(A)	1.0	.500	.033	.500	.078	.356	.033	.187

NOTE--Biserial Correlations 111EA-Totals Were Raw Scores.

March 17, 1969 Baldwin ACH MEAS Student Dynamic CRIT IS TOT SCR JT2151

Item Information

Item Number	Correct Response	Weight	Proportion Passing	Proportion Omitting	Proportion Of Selecting Each Response A	B	C	D	Biserial R Item-Total
1	(B)	1.0	.545	.000	.330	.545	.011	.114	.495
2	(D)	1.0	.455	.000	.159	.182	.205	.455	.068
3	(D)	1.0	.693	.000	.011	.011	.284	.693	.449
4	(A)	1.0	.705	.000	.705	.091	.034	.170	.613
5	(A)	1.0	.364	.000	.364	.136	.455	.045	.238
6	(B)	1.0	.477	.000	.193	.477	.284	.045	.081
7	(D)	1.0	.557	.000	.170	.239	.034	.557	.516
8	(D)	1.0	.830	.000	.000	.000	.170	.830	.060
9	(A)	1.0	.250	.000	.250	.523	.205	.023	.777
10	(D)	1.0	.250	.000	.182	.545	.023	.250	.429
11	(C)	1.0	.489	.000	.057	.250	.489	.205	.351
12	(A)	1.0	.499	.000	.455	.182	.307	.057	.180
13	(A)	1.0	.511	.000	.511	.330	.102	.057	.596
14	(C)	1.0	.281	.000	.568	.136	.261	.034	-.318
15	(B)	1.0	.705	.000	.148	.705	.068	.080	.461
16	(C)	1.0	.852	.000	.011	.114	.852	.023	.393
17	(D)	1.0	.636	.000	.080	.034	.250	.636	.523
18	(C)	1.0	.898	.000	.057	.023	.898	.023	.645
19	(D)	1.0	.148	.000	.125	.148	.580	.148	.321
20	(D)	1.0	.500	.000	.102	.023	.375	.500	.516
21	(D)	1.0	.307	.000	.023	.591	.080	.307	.799
22	(B)	1.0	.534	.000	.216	.534	.182	.068	.596
23	(A)	1.0	.170	.000	.170	.045	.398	.386	.344
24	(C)	1.0	.250	.000	.068	.125	.250	.557	.334
25	(D)	1.0	.523	.011	.114	.148	.205	.523	.172
26	(D)	1.0	.386	.000	.284	.227	.102	.386	.362
27	(A)	1.0	.807	.000	.807	.102	.034	.057	.462
28	(B)	1.0	.511	.011	.205	.511	.148	.125	.329
29	(D)	1.0	.557	.011	.170	.193	.068	.557	.531
30	(C)	1.0	.670	.000	.034	.057	.670	.239	.567

March 17, 1969 Baldwin ACH MEAS Student Dynamic CRIT IS TOT SCR JT2151

Item Information

Item Number	Correct Response	Weight	Proportion Passing	Proportion Omitting	Proportion Of Selecting Each Response A	B	C	D	Biserial R Item-Total
31	(B)	1.0	.841	.000	.057	.841	.091	.011	.376
32	(B)	1.0	.588	.000	.091	.568	.148	.193	.456
33	(D)	1.0	.937	.000	.023	.000	.045	.932	.359
34	(A)	1.0	.602	.000	.602	.034	.057	.307	.455
35	(B)	1.0	.648	.000	.023	.648	.057	.273	.083
36	(B)	1.0	.352	.000	.273	.352	.091	.284	.540
37	(D)	1.0	.420	.000	.114	.375	.091	.420	.109
38	(D)	1.0	.455	.000	.011	.159	.375	.455	.378
39	(B)	1.0	.739	.000	.080	.739	.068	.114	.238
40	(A)	1.0	.307	.000	.307	.523	.159	.011	-.123
41	(A)	1.0	.466	.000	.466	.205	.182	.148	.451
42	(D)	1.0	.682	.000	.045	.023	.250	.682	.517
43	(A)	1.0	.114	.011	.114	.136	.489	.250	.069
44	(B)	1.0	.534	.000	.045	.534	.318	.102	.130
45	(D)	1.0	.898	.000	.034	.057	.011	.898	.160
46	(D)	1.0	.830	.000	.091	.034	.045	.830	.242
47	(A)	1.0	.125	.000	.125	.466	.045	.364	.052
48	(C)	1.0	.205	.000	.330	.398	.205	.068	-.229
49	(D)	1.0	.739	.000	.091	.091	.080	.739	.121
50	(A)	1.0	.489	.000	.489	.148	.318	.045	.094

NOTE--Biserial Correlations (Item Total) Were With Raw Scores.

March 17, 1969 Baldwin ACH MEAS Student Static CRIT IS TOT SCR JT2151

FACTOR ANALYSIS

ROTATED FACTORS

Item	Communality	1	2	3	4
1	.6011	.7354	-.0322	+.0304	.2416
2	.3034	.2301	+.2176	-.4478	-.0506
3	.1872	.1576	-.4026	-.0006	-.0162
4	.0811	.0850	-.1614	-.0673	.2081
5	.4766	.2069	+.6387	+.1588	-.0268
6	.4489	-.2099	+.1263	+.6236	.0032
7	.6437	.4410	+.6676	-.0412	.0424
8	.0366	.0994	+.1343	-.0465	.0809
9	.3417	.4688	+.3239	-.0661	.1127
10	.2487	.2738	-.3783	-.1747	.0117
11	.3346	.5152	-.1159	-.1815	-.1508
12	.3604	.4834	-.0025	-.2226	.2776
13	.5242	.4456	+.2497	-.1982	.4732
14	.2512	-.0558	-.0282	-.4972	.0043
15	.1601	.1181	+.1235	-.3614	-.0187
16	.0619	.1159	+.0295	-.0748	.2050
17	.3641	.5060	+.0457	+.2347	.2256
18	.2025	.1294	-.0336	+.1379	.4070
19	.0188	-.0855	+.0206	-.0907	.0533
20	.6515	.6756	-.3359	+.0235	.2858
21	.3612	.5550	+.2051	+.0961	.0435
22	.3836	.3135	+.0212	+.3702	.3845
23	.0323	-.0562	-.0879	+.0901	.1152
24	.3159	.2821	+.1688	+.4345	.1378
25	.2665	.3661	+.0338	+.0634	.3568
26	.2498	.4284	+.0058	-.1574	-.2035
27	.2124	.4253	+.0732	+.0021	.1616
28	.2340	-.0152	+.0045	+.3592	-.3236
29	.5750	-.1874	+.4940	-.0367	.5427
30	.1874	.1937	+.2479	-.0373	.2949

March 17, 1969 Baldwin ACH MEAS Student Static CRIT IS TOT SCR JT2151

FACTOR ANALYSIS

ROTATED FACTORS

Item	Communality	1	2	3	4
31	.1130	.0304	+.0026	-.0389	-.3326
32	.4108	.4964	+.3526	+.1882	-.0685
33	.0741	.1929	+.0714	+.1651	-.0673
34	.4450	.2722	-.0585	+.5387	.2779
35	.1127	.0215	+.3088	+.0451	.1219
36	.3942	.2012	+.5712	+.0932	.1370
37	.1037	.2552	-.1327	+.0010	-.1446
38	.3654	.4738	-.3227	+.1737	.0815
39	.0749	.0721	-.2063	+.1126	.1204
40	.1387	.1758	+.0358	-.3145	-.0870
41	.2271	-.0470	+.0371	-.0388	.4712
42	.5598	.6932	+.2438	-.0744	.1196
43	.1169	-.1598	-.0253	-.2899	.0821
44	.1981	.0578	+.0371	+.4131	-.1509
45	.2095	-.0240	+.1079	-.0572	.4405
46	.2130	.1498	+.2252	+.0489	.3707
47	.0222	.0413	-.0135	+.1419	.0115
48	.1930	-.2101	+.1504	+.3197	-.1552
49	.1758	.3706	+.0859	+.1699	-.0471
50	.0872	.1917	+.0264	+.0351	-.2202
Sum SQ	13.3514	5.2167	2.8481	2.6774	2.6092

March 17, 1969 Baldwin ACH MEAS Student Dynamic CRIT IS TOT SCR JT2151

FACTOR ANALYSIS

ROTATED FACTORS

Item	Communality	1	2	3	4
1	.4509	.4371	+.4213	-.1531	+.2426
2	.4004	-.1336	-.2822	.5437	-.0859
3	.2714	.4693	-.1063	-.1995	+.0065
4	.2580	.4689	+.0375	.1915	-.0071
5	.1920	.1647	+.1512	.0109	-.3766
6	.2955	.1223	+.1028	-.4452	-.2679
7	.3278	.5605	-.0831	-.0121	-.0811
8	.0838	-.0228	-.0005	.2855	-.0413
9	.4504	.6669	-.0345	.0637	+.0185
10	.1419	.3650	-.0313	.0700	-.0529
11	.2362	.2620	+.0972	.1923	+.3480
12	.3704	.1123	+.1229	.1297	+.5708
13	.4321	.5968	+.0090	.2513	+.1128
14	.2596	-.3577	-.3527	-.0778	+.0346
15	.2589	.4258	-.1780	.0362	+.2113
16	.0549	.1980	+.1127	-.0016	-.0547
17	.4267	.4493	+.3214	.0871	+.3375
18	.0720	.2549	+.0719	-.0434	+.0016
19	.1202	.0891	+.1469	.0670	+.2935
20	.2662	.4424	+.2091	.0604	+.1519
21	.5067	.6988	+.0660	.0912	-.0758
22	.3178	.4200	+.2792	.2516	-.0141
23	.1733	.2765	-.1321	-.1947	+.2036
24	.2805	.1547	+.4448	-.0821	-.2279
25	.1423	.1833	-.0525	.3049	+.1141
26	.2649	.3121	-.2878	.2908	+.0062
27	.1909	.2296	+.1644	.2375	+.2340
28	.2002	.4006	-.0163	-.1736	-.0965
29	.2834	.5053	+.1060	-.1297	-.0023
30	.3099	.3753	+.1329	.3820	-.0741

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FACTOR ANALYSIS

ROTATED FACTORS

Item	Communality	1	2	3	4
31	.1356	.0787	-.0581	.3268	-.1387
32	.4695	.5572	+.2483	-.1510	+.2731
33	.0085	.0693	+.0021	.0093	-.0600
34	.4137	.2731	+.4551	.3584	+.0598
35	.5206	-.1477	+.5528	.4042	-.1725
36	.5040	.4116	+.2076	.5347	-.0747
37	.3354	-.0444	+.2121	.1250	-.5224
38	.5466	.3758	-.0555	-.0494	-.6323
39	.2084	.1028	-.2373	.2396	+.2900
40	.2210	-.0662	-.4629	-.0465	-.0136
41	.2114	.3752	+.0979	.0414	-.2437
42	.4225	.4556	-.4004	.2069	-.1087
43	.0784	.0104	+.1774	-.0813	+.2004
44	.1883	-.1057	+.4093	-.0971	-.0128
45	.0227	-.0101	-.0092	.1440	+.0420
46	.0550	.0634	-.0174	.0043	-.2251
47	.0471	-.0122	-.0950	-.1443	-.1310
48	.2409	-.1768	-.4008	-.1139	-.1897
49	.0923	-.0078	+.2527	-.1290	+.1082
50	.4069	.2321	-.1478	-.5078	-.2708
Sum SQ	13.1679	5.5402	2.6831	2.5442	2.4004

APPENDIX C

SAMPLE TEST ITEMS

SAMPLE TEST ITEMS

35. The most likely cause of the malfunction in Figure #16 with normal audio is:

    A. defective video amplifier
    B. defective horizontal oscillator (Horizontal motion is present.)*
    C. defective integrator circuit
    D. defective sync circuit

37. The most likely cause of the malfunction in Figure #17 with normal audio is:

    A. defective integrator circuit
    B. defective vertical oscillator (Vertical motion is presented.)
    C. defective height pot
    D. defective vertical linearity pot

45. The most likely cause of the malfunction in Figure #24 with normal audio is:

    A. defective integrator circuit
    B. defective differentiator circuit (Horizontal and vertical motion is presented.)
    C. defective DC power supply
    D. defective sync-AGC circuit

50. The most likely cause of the malfunction in Figure #27 with normal audio is:

    A. increased capacitance in deflection yoke circuit
    B. shorted vertical output winding
    C. defective damper
    D. defective high voltage rectifier

*In the static test, when a motion cue was necessary, it was given beside the photograph rather than in the question.